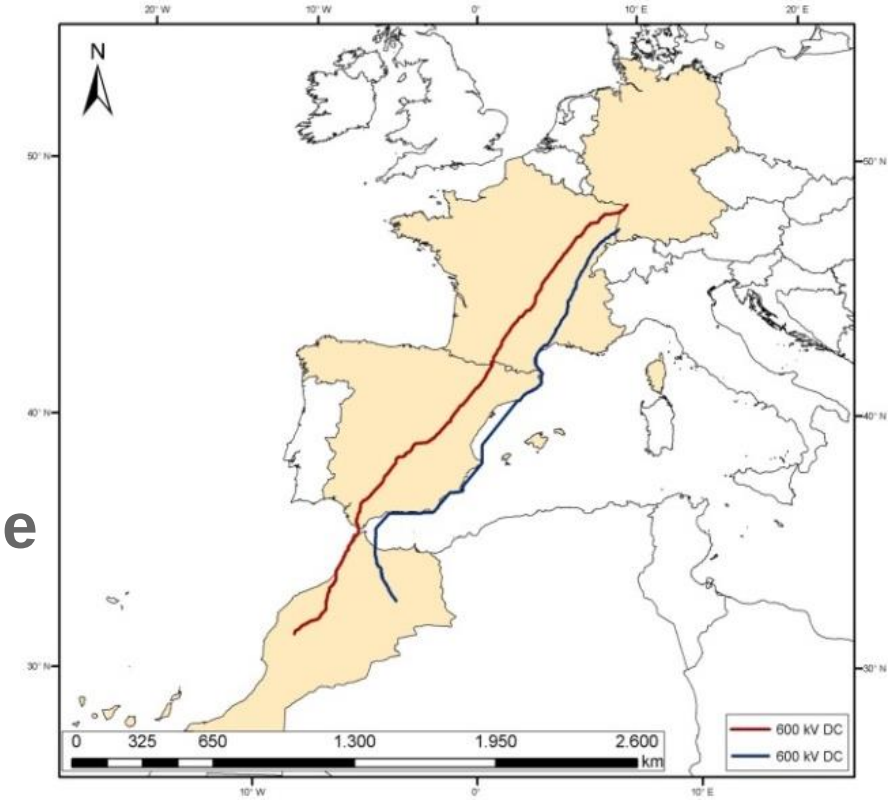
Transmission of dispatchable solar energy from North Africa to Central Europe



Dipl.-Ing. Denis Hess
Lyon, 07.10.2013

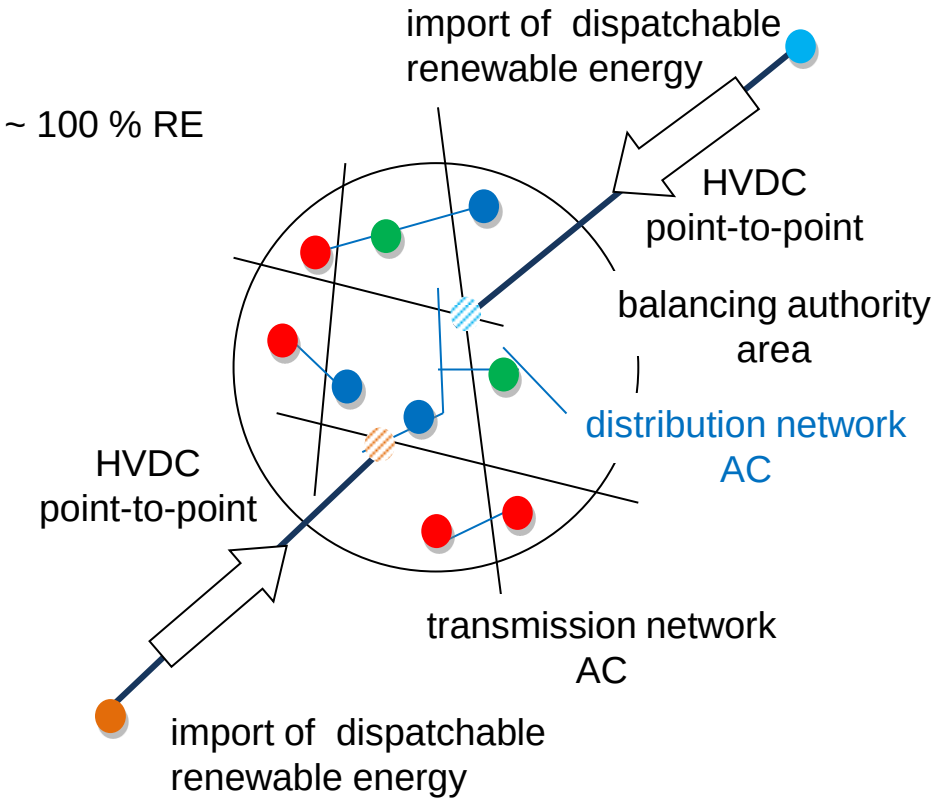
DLR

Examination area - BW

decentralized renewable energies (RE) and storages

large power plants of dispatchable renewable energies

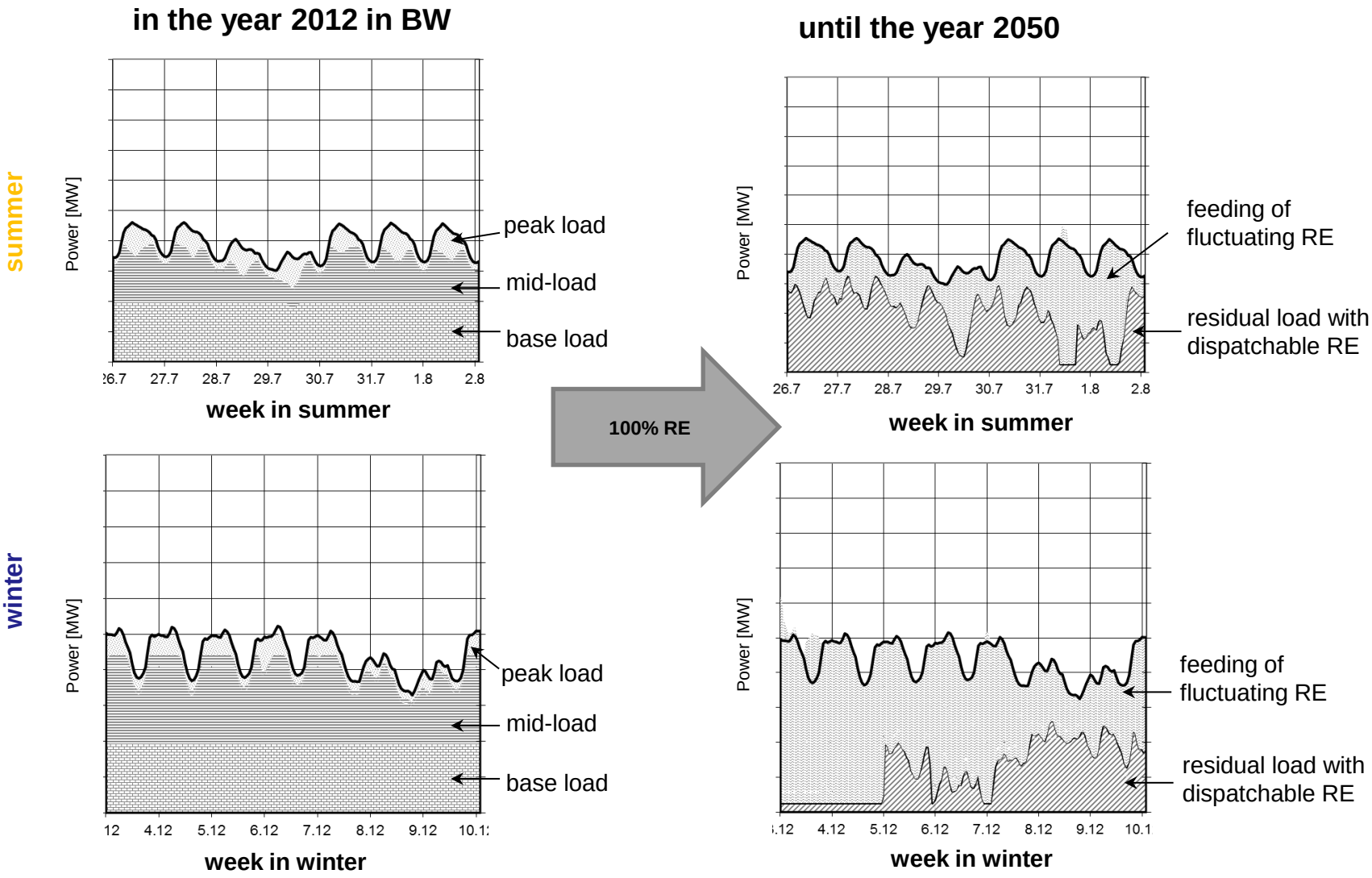
feeding point into the AC grid



10.8 mio. inhabitants, 80 TWh/y - in the year 2012

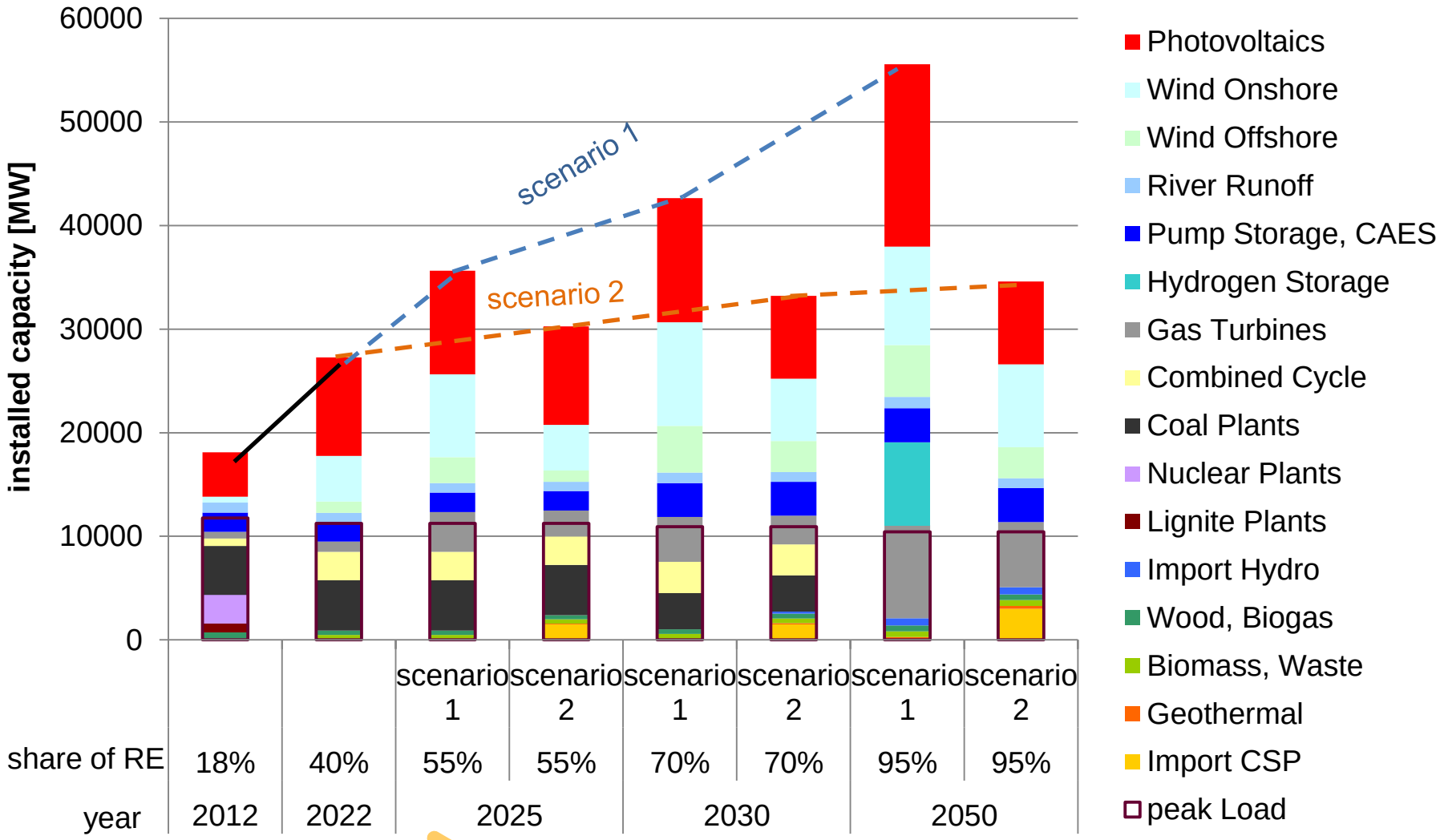
Source: (http://de.wikipedia.org/wiki/Baden-W%C3%BCrttemberg)

Paradigm change in the load range



Quelle: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

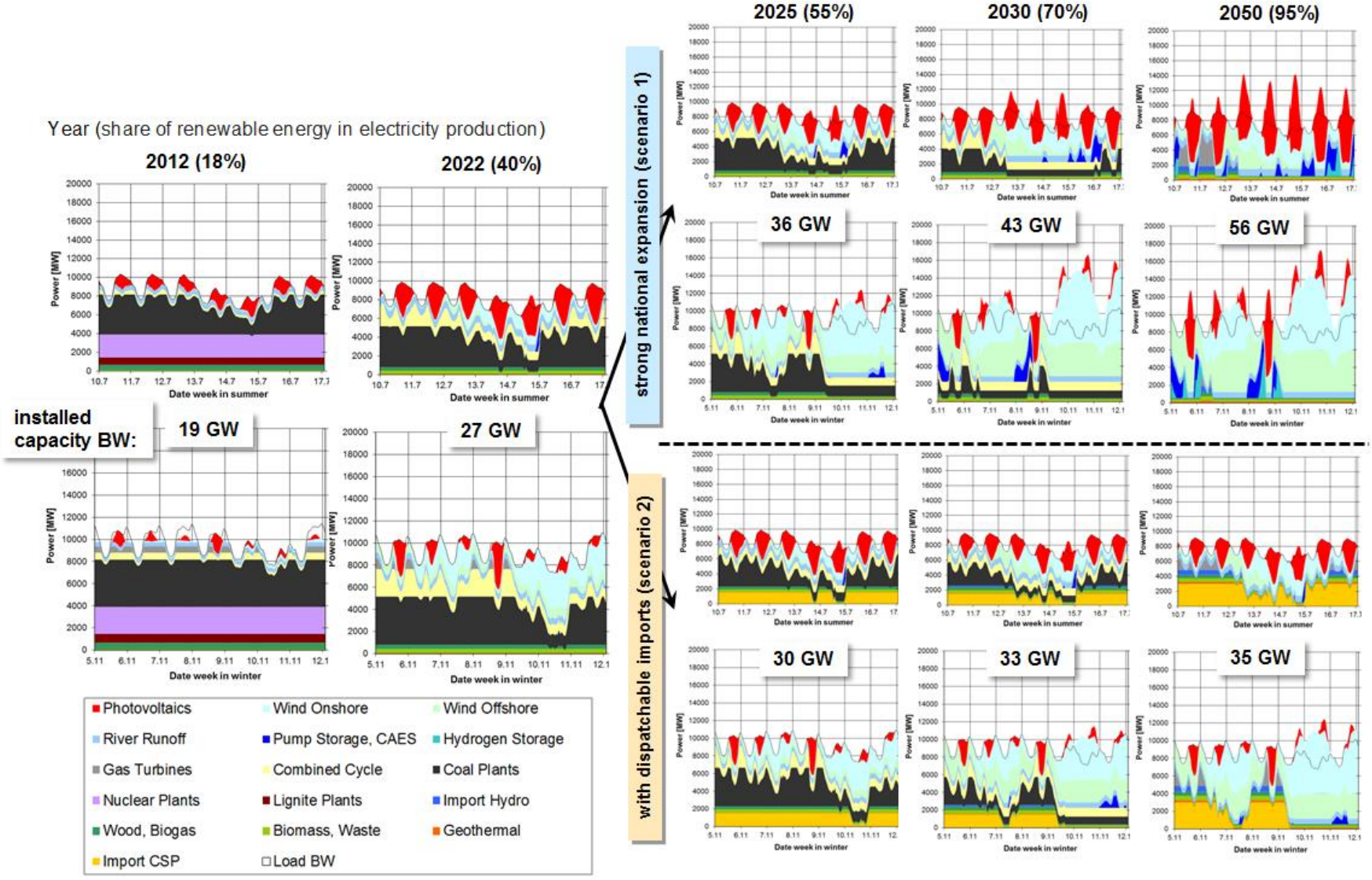
Renewable energies for Baden-Württemberg



The decision for scenario 2 is already TODAY necessary!

Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

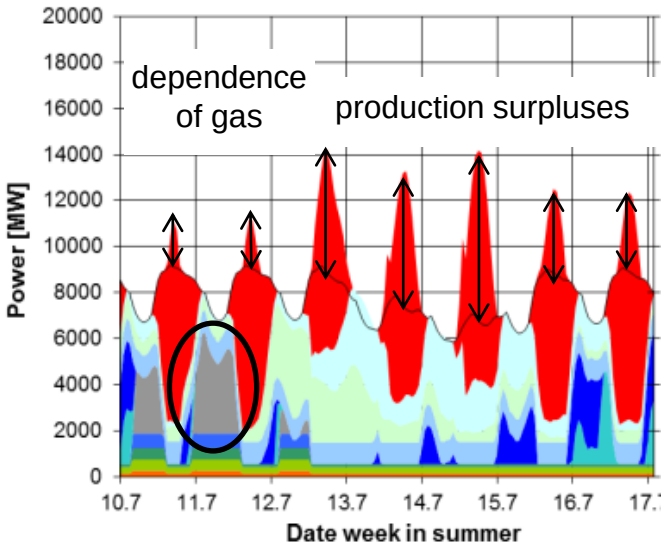
Time series of power production by type of power plant



Source: Hess, D., Trieb, F., 2013, Fernübertragung regelbarer Solarenergie

System problems in Baden-Württemberg in the year 2050 with 95% renewable energy (RE) in electricity supply

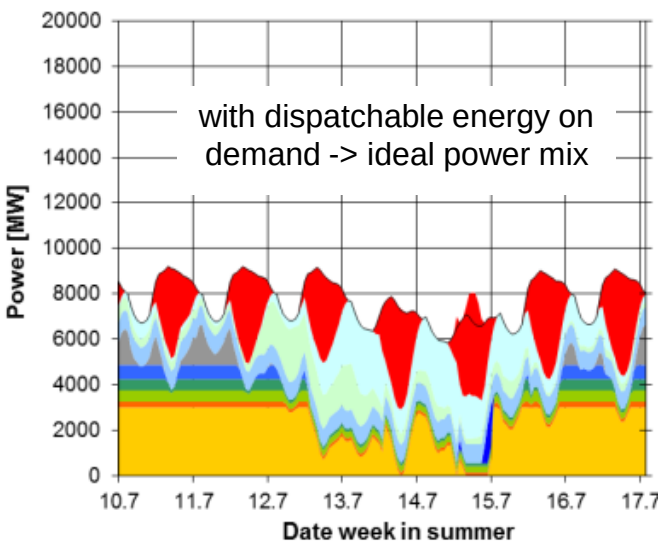
installed capacity: 55 GW

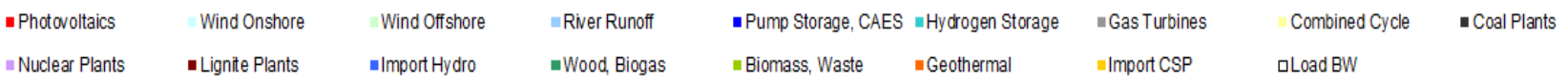


Quo vadis?

2050 95% RE

installed capacity: 35 GW



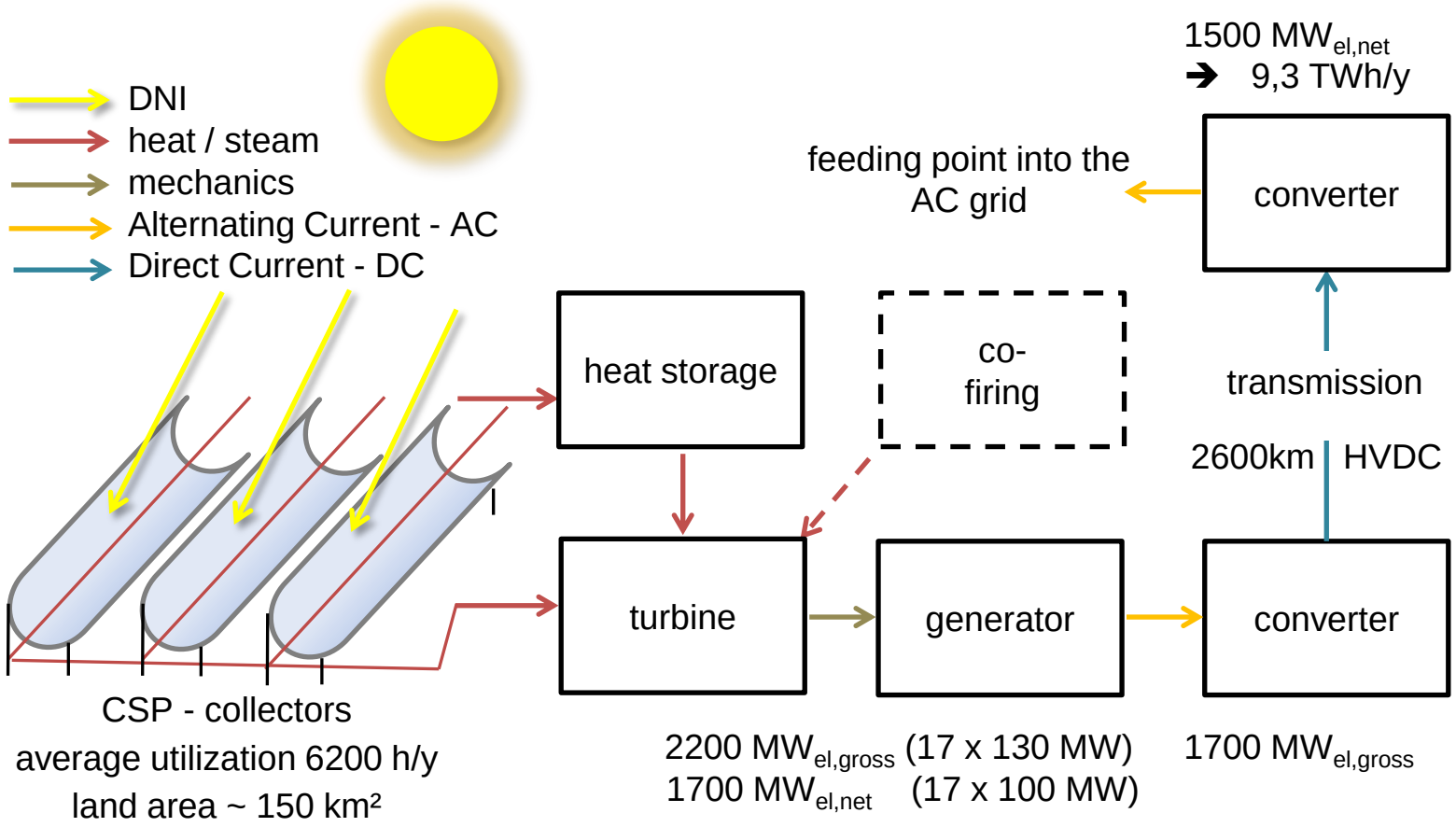


Two scenarios for the year 2050, each with 95% renewable energies for the electricity supply in Baden-Württemberg

Today, the decision must be made specifically for the choice of one way!

Source: Hess, D., Trieb, F., 2013, Fernübertragung regelbarer Solarenergie

Transmission of dispatchable solar energy: CSP-HVDC site



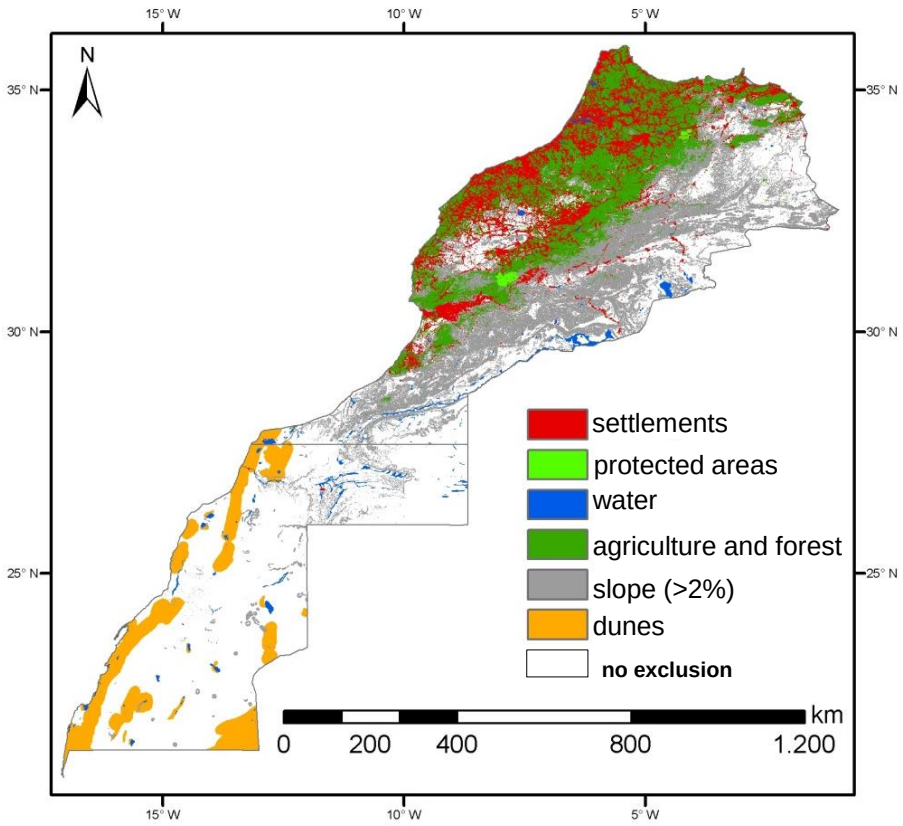
DNI: Direct Normal Irradiance
CSP: Concentrating Solar Power
HVDC: High Voltage Direct Current

Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

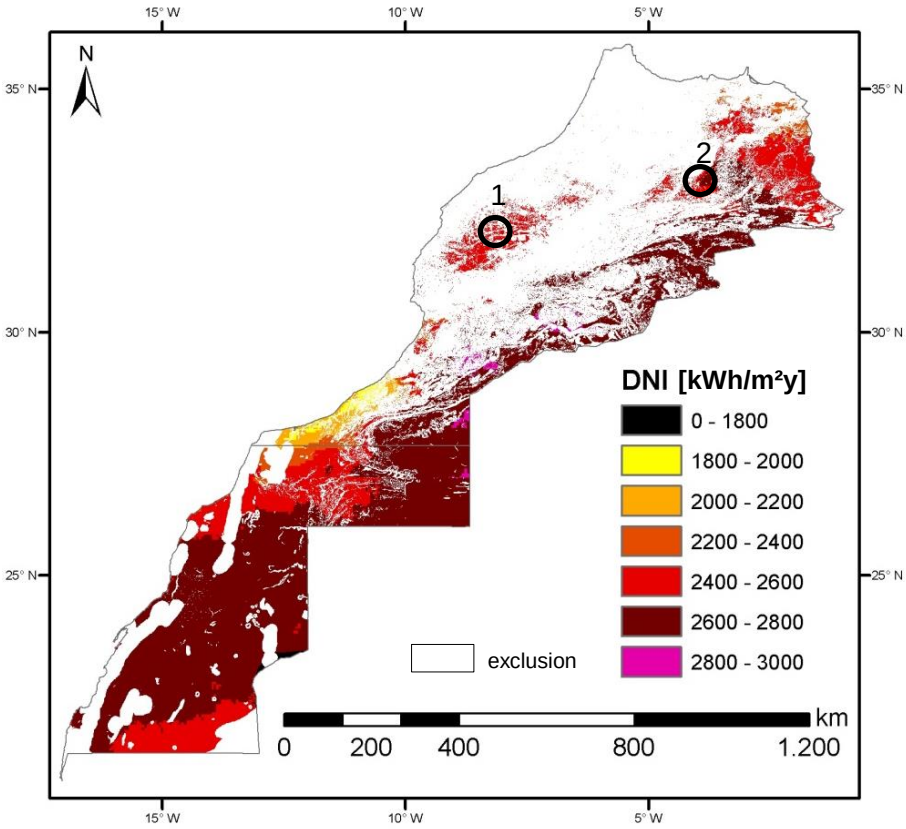
Morocco

! The sites are just scientific !

Exclusion areas



Economic possible sites



The economic **CSP potenital** in the northern part of Morocco is at about **8450 TWh/y** with **18500 km²** CSP gross land demand

-> one site with 150 km² needs **only 0.8% of this potential**

Source: Hess, D., Fichter, T., 2013, Fernübertragung regelbarer Solarenergie

First design of the CSP-HVDC site, cost and land requirements

MOR-E-F-D

HVDC 2600 km
1.7 GW / 1.5 GW_{net}
3 billion €
150 km²

CSP 2.2 GW
CSP 12 -18 billion €
150 km²

MOR-E-F-D

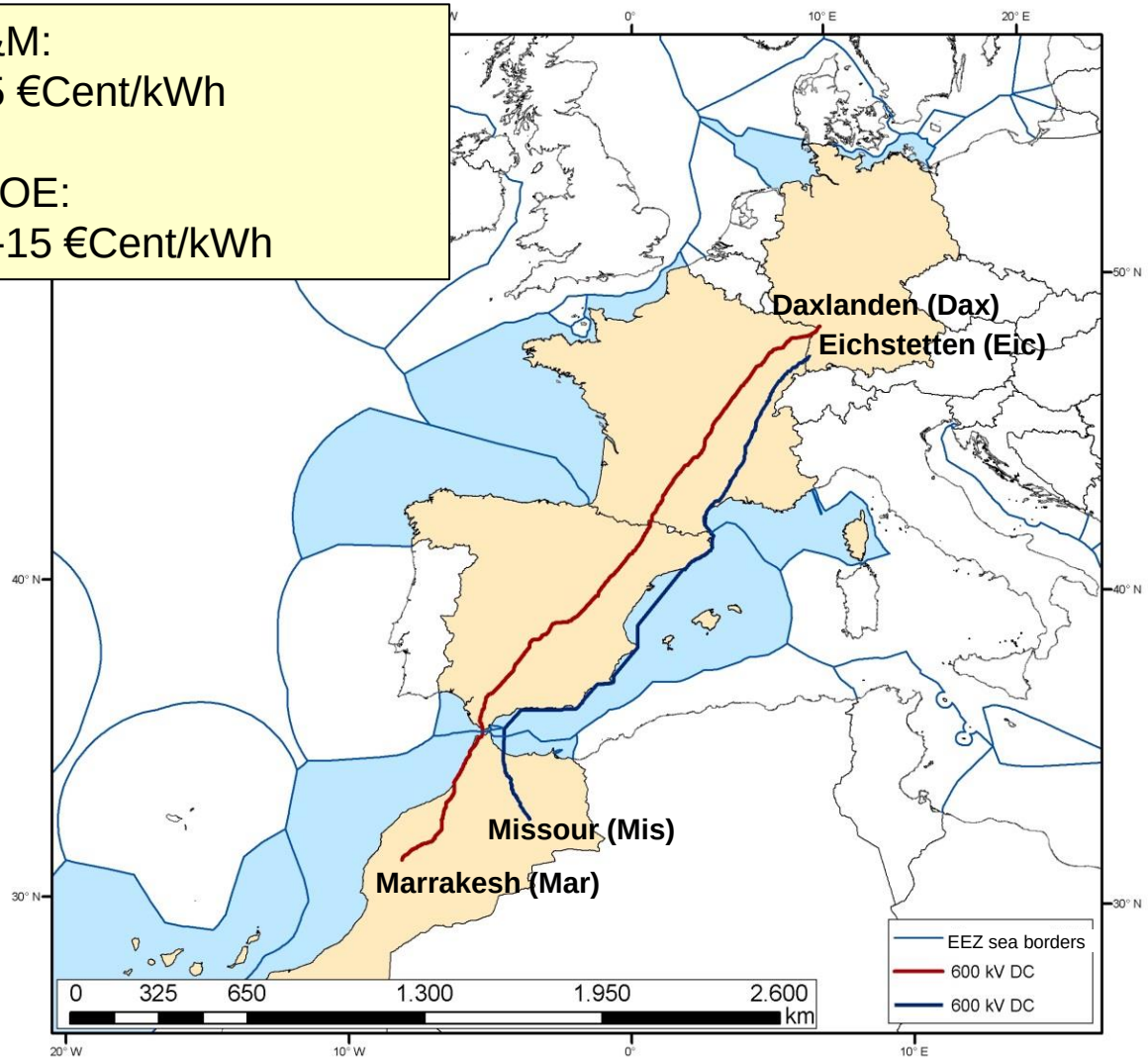
HVDC 2300 km
1.7 GW / 1.5 GW_{net}
5.1 - 6 billion €
75km²

CSP 2.2 GW
CSP 12 -18 billion €
150 km²

-> 9.32 TWh/a
16-24 billion € (real 2010)
feasible until 2024

O&M:
4-5 €Cent/kWh

LCOE:
12-15 €Cent/kWh



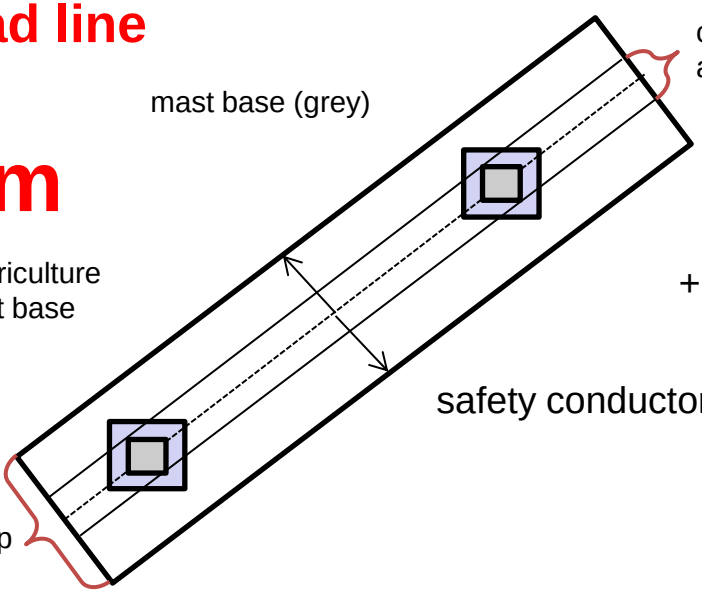
Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

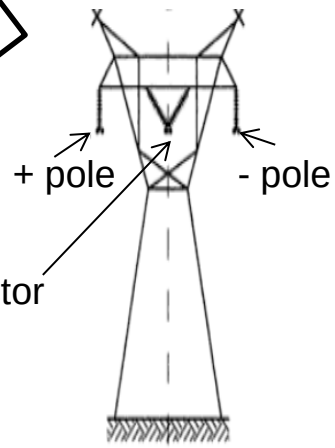
Adequate permanent payment for the required land

Overhead line

70 m

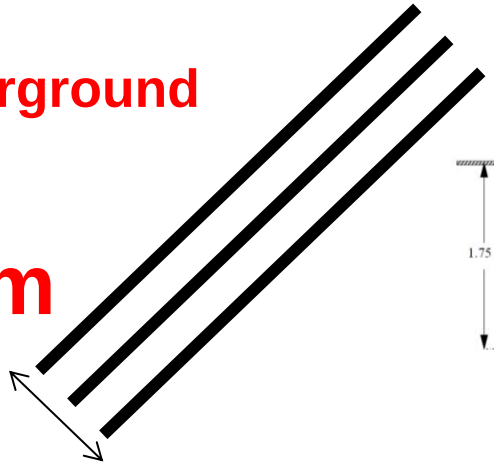
Restriction of agriculture through the mast base (blue)

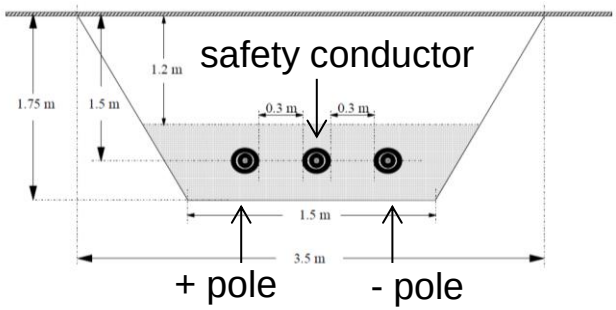




Underground cable

4 m





unit

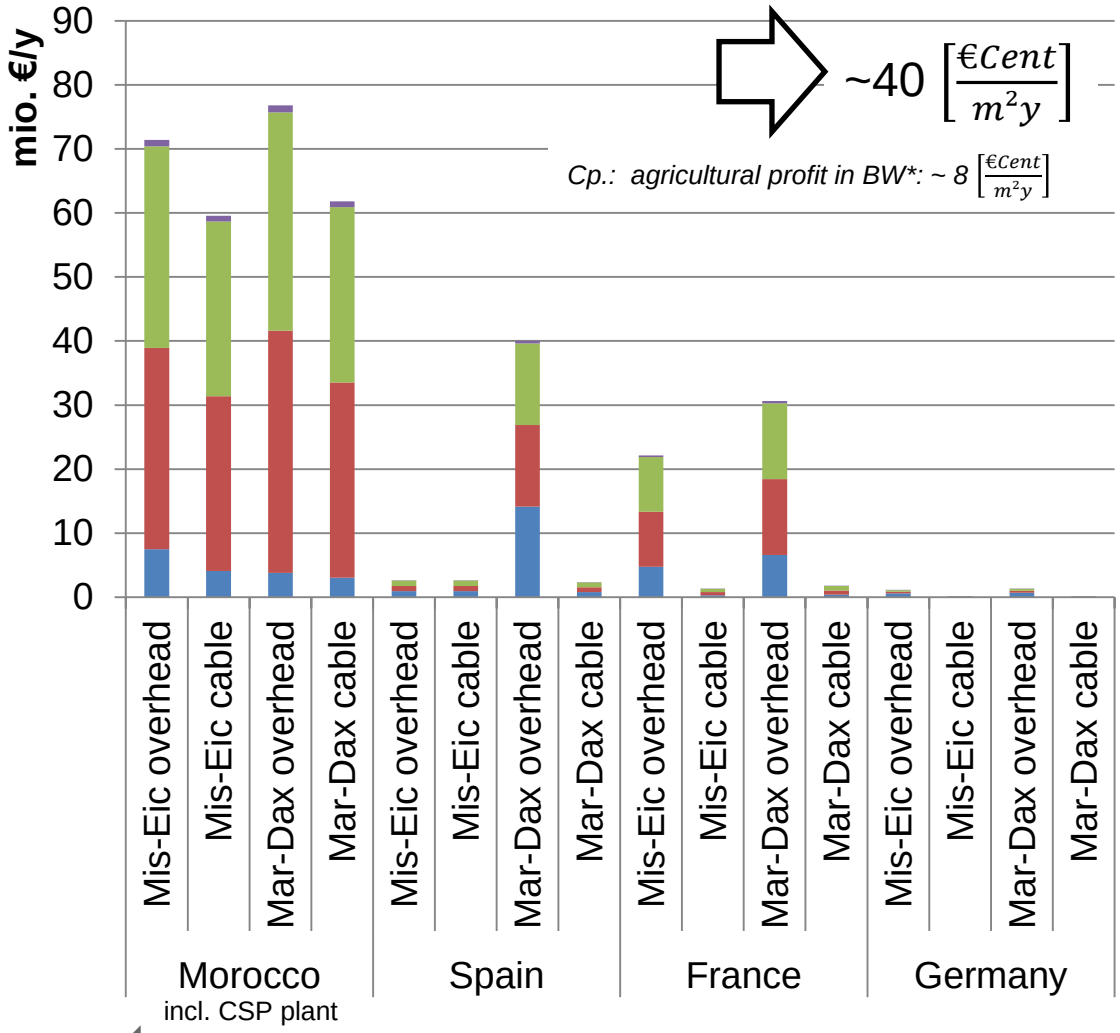
$$\left[\frac{€Cent}{TWh \cdot m^2 \cdot y}\right]$$

cheaper overhead line and more expensive underground cable can reach through this compensation payment **cost neutrality** within their lifetime!

free choice of technology is made possible -> increased acceptance

Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

Annual income for the concerned nations, their municipalities and landowners (riparians) – each time with 4 routes



~40 $\left[\frac{€Cent}{m^2y}\right]$

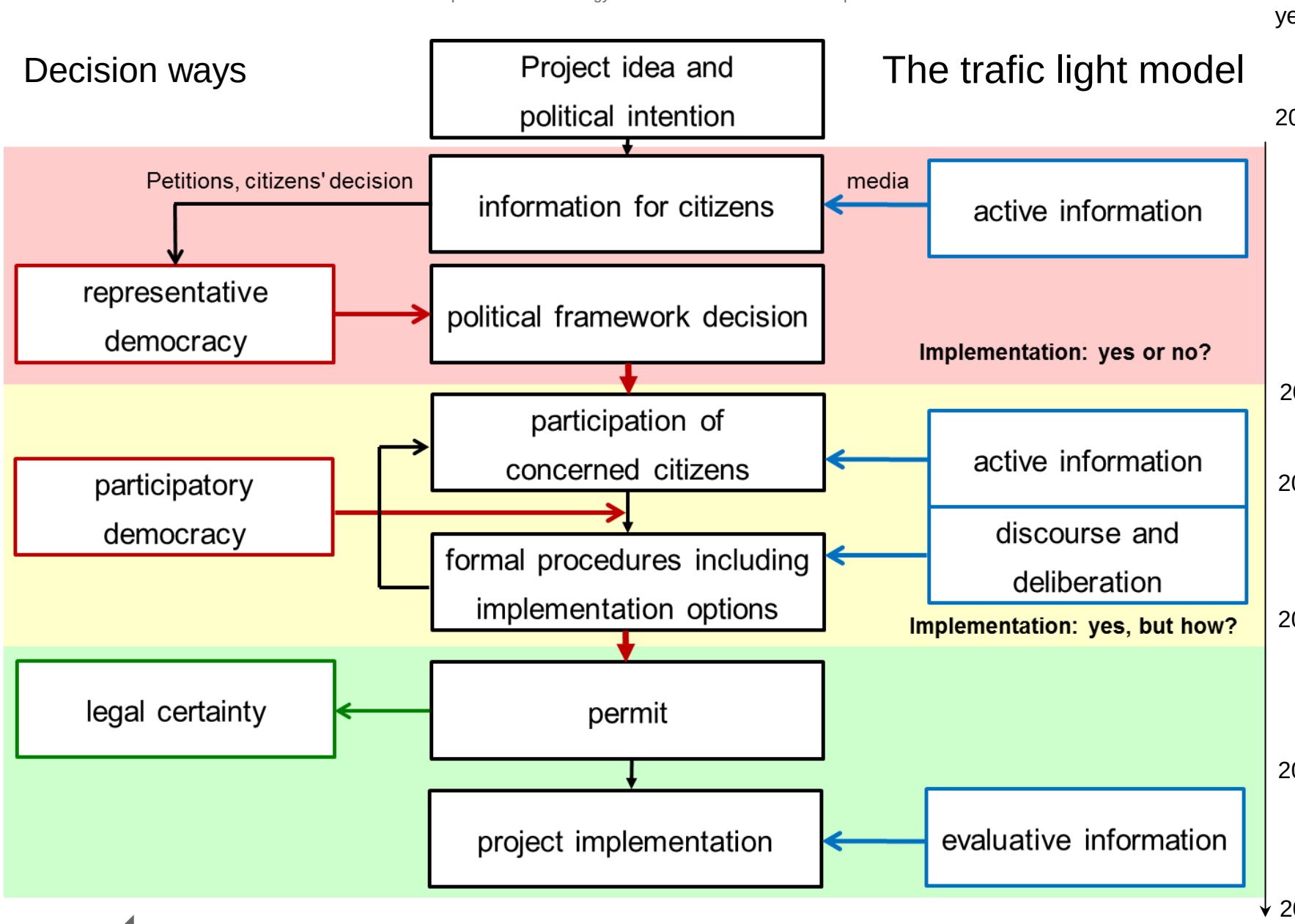
Cp.: agricultural profit in BW: ~ 8* $\left[\frac{€Cent}{m^2y}\right]$

0.67 – 1.56 $\left[\frac{€Cent}{kWh}\right]$
costs for the consumers

- annual income for the nations and their municipalites from the concession fee
- annual income for the nations and their municipalites from tax of the motivation payment
- annual income for the landowners from the motivation payment
- annual income for the landowners from the decreasing value

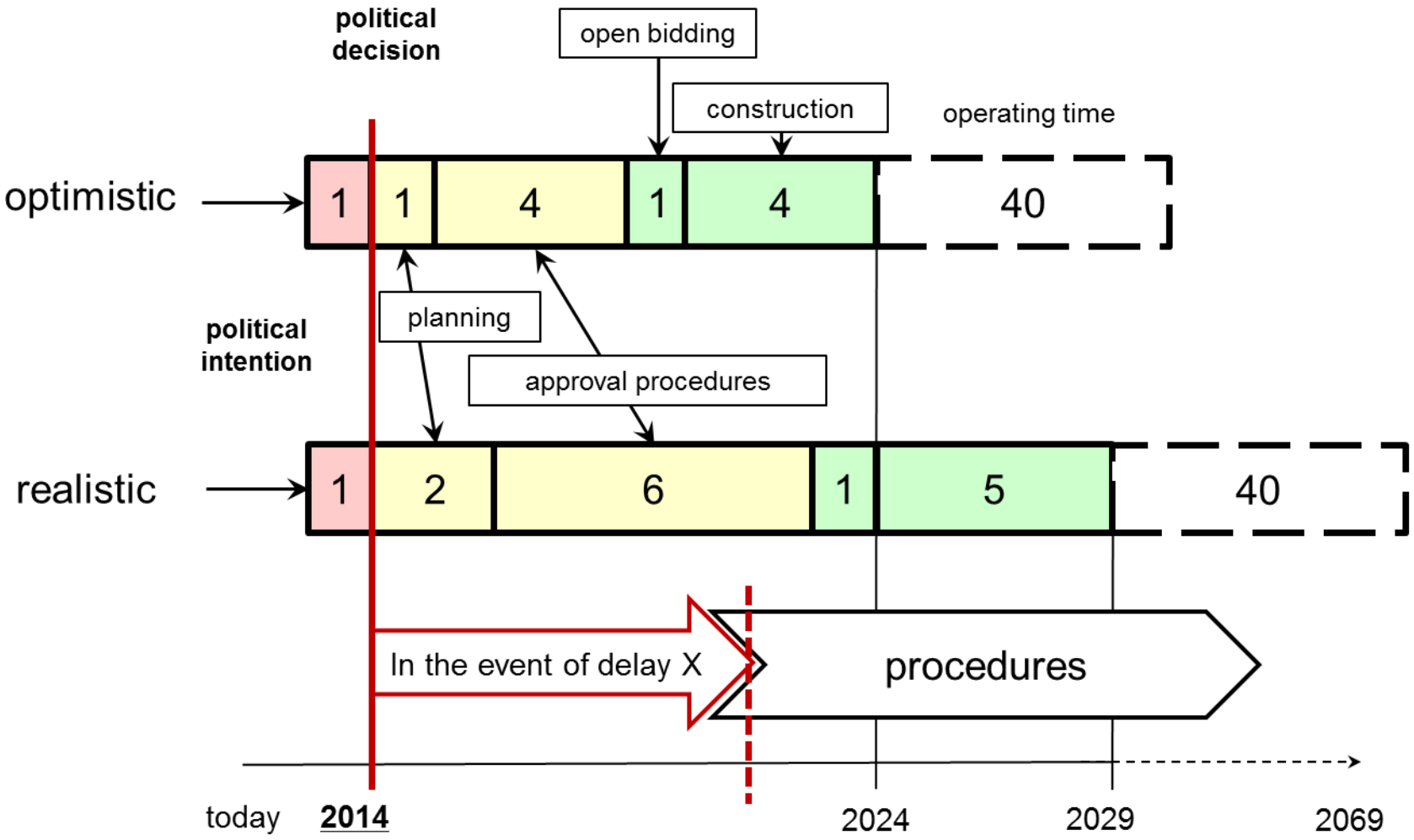
Today only the blue value is paid for the construction of transmission lines in Germany **ONCE**!

Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie
*Landwirtschaftliche Betriebsverhältnisse und Buchführungsergebnisse 2012



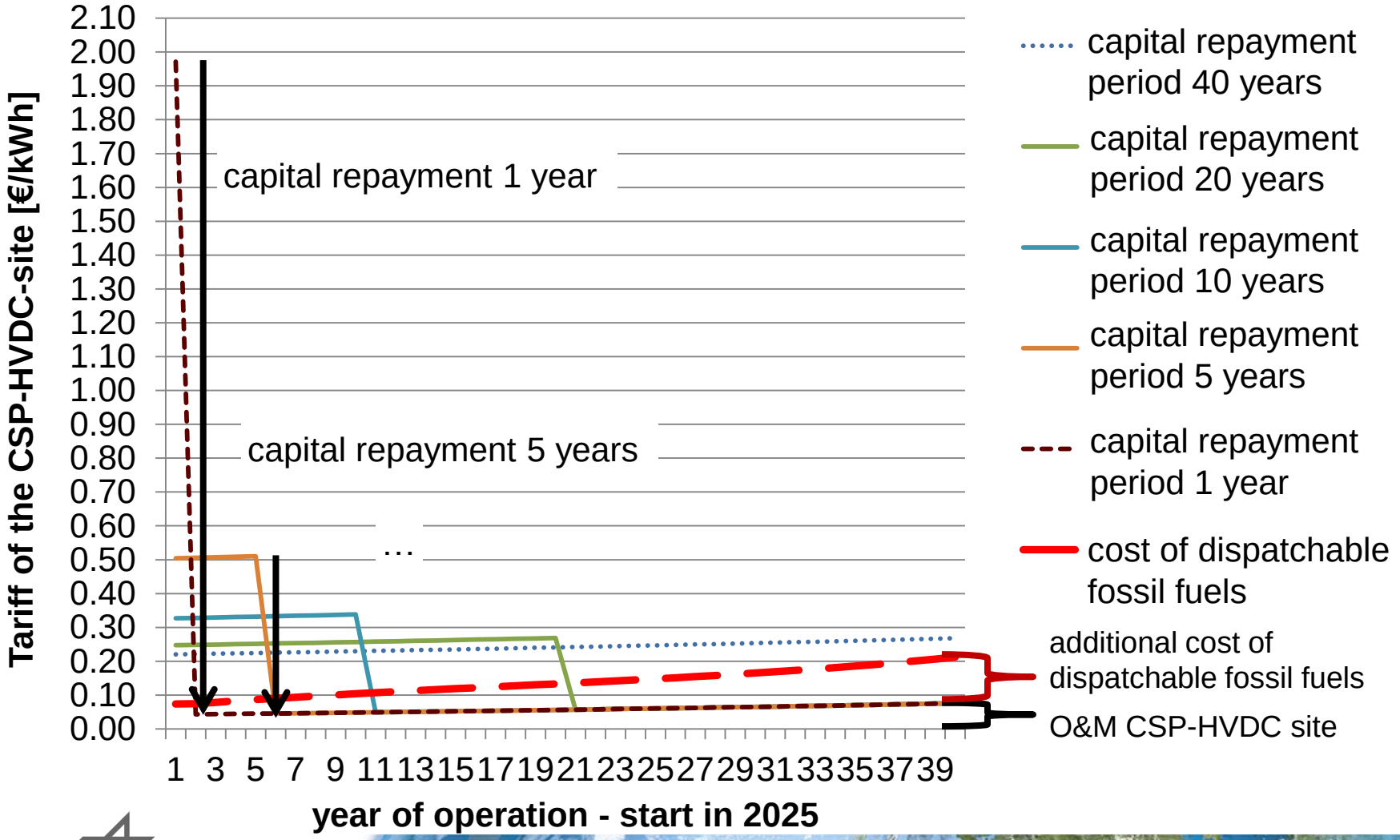
Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

Time limit for a decision



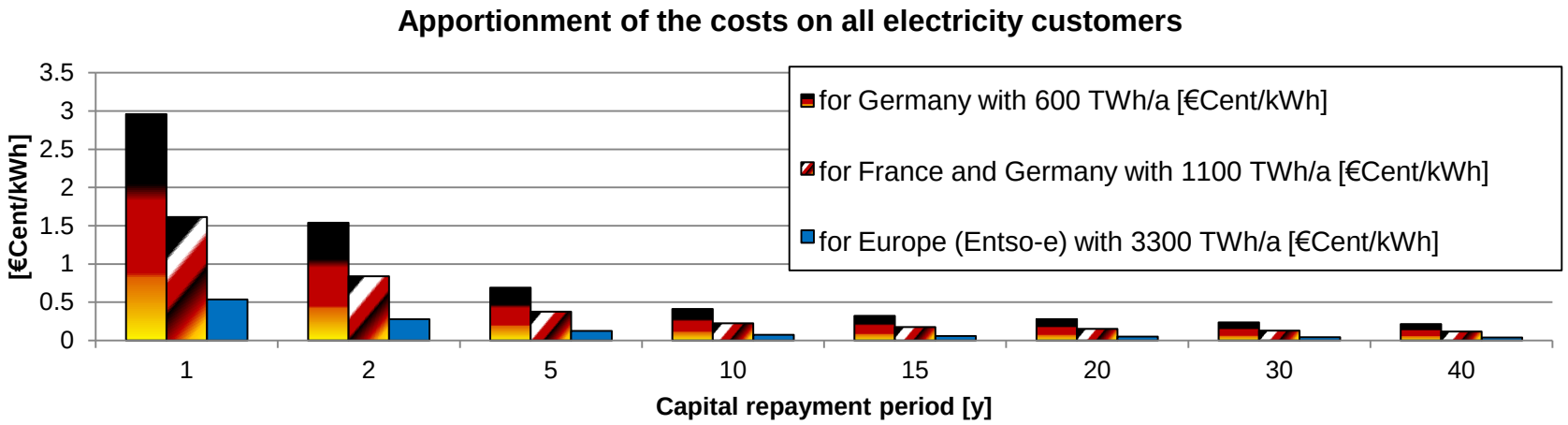
Source: Drees&Sommer, Dr. Uwe Knauer 2013

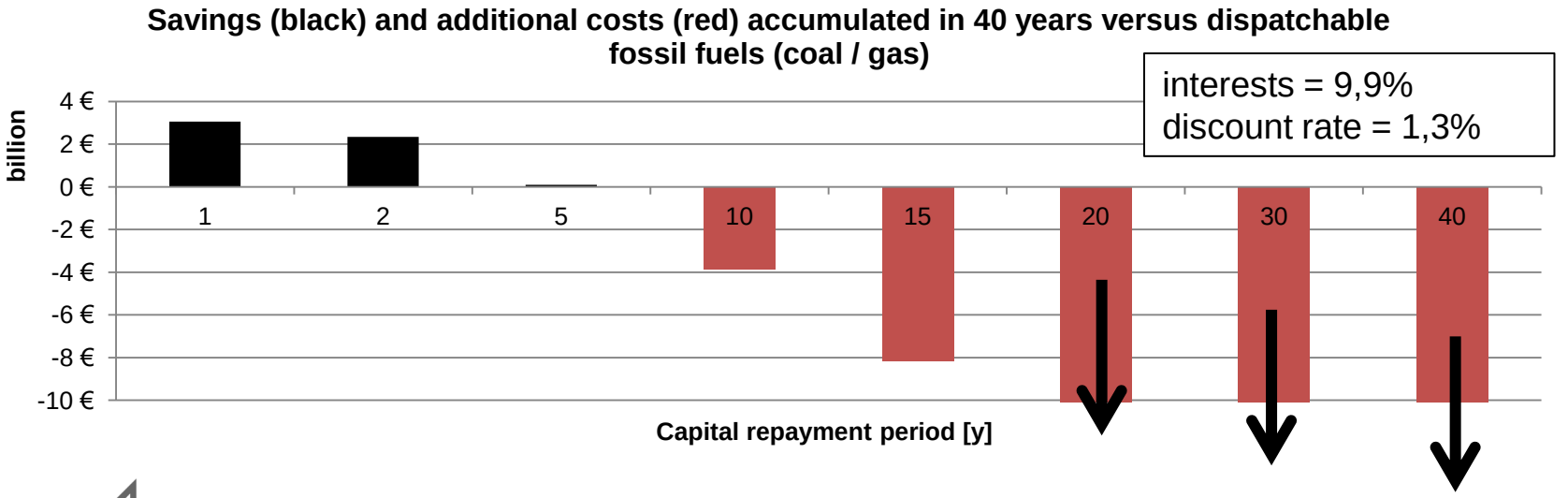
Tariff of the CSP-HVDC site Mis-Eic with underground cable - How can 16 billion € be paid that low interests incurred and thus the capital costs remain low?



Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

How can 16 billion € be paid that low interests incurred and thus the capital costs remain low?

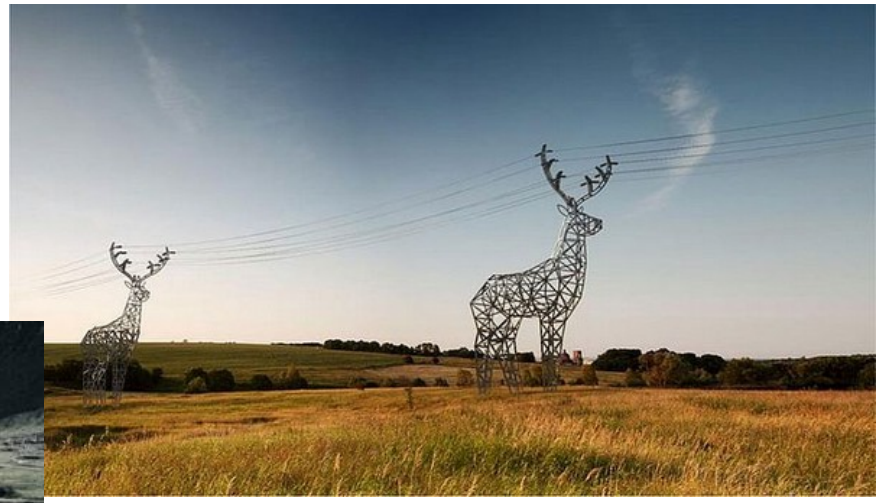


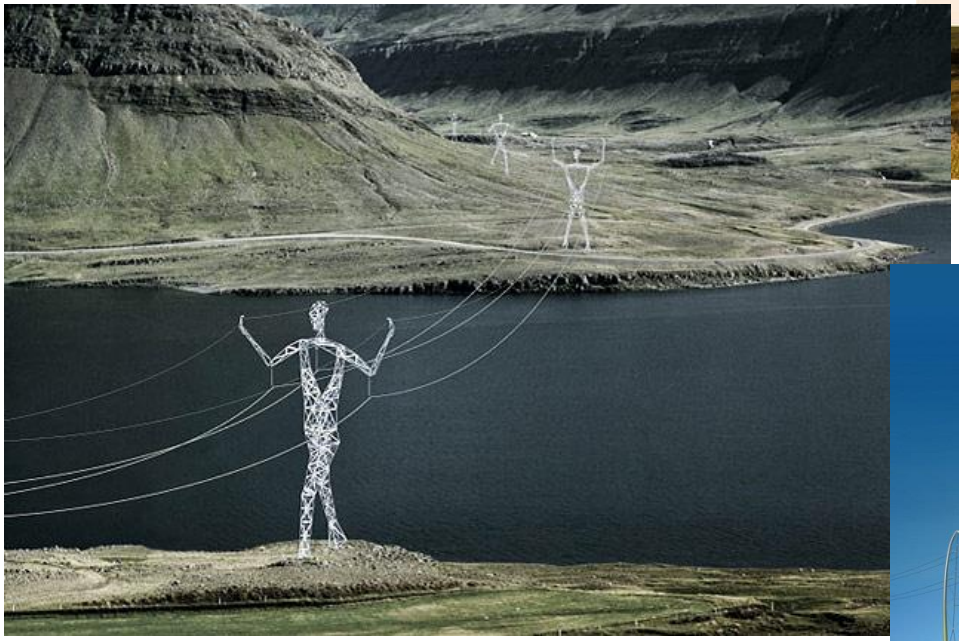


Source: Hess, D., 2013, Fernübertragung regelbarer Solarenergie

„Ways connect people“

Thank you for your attention!





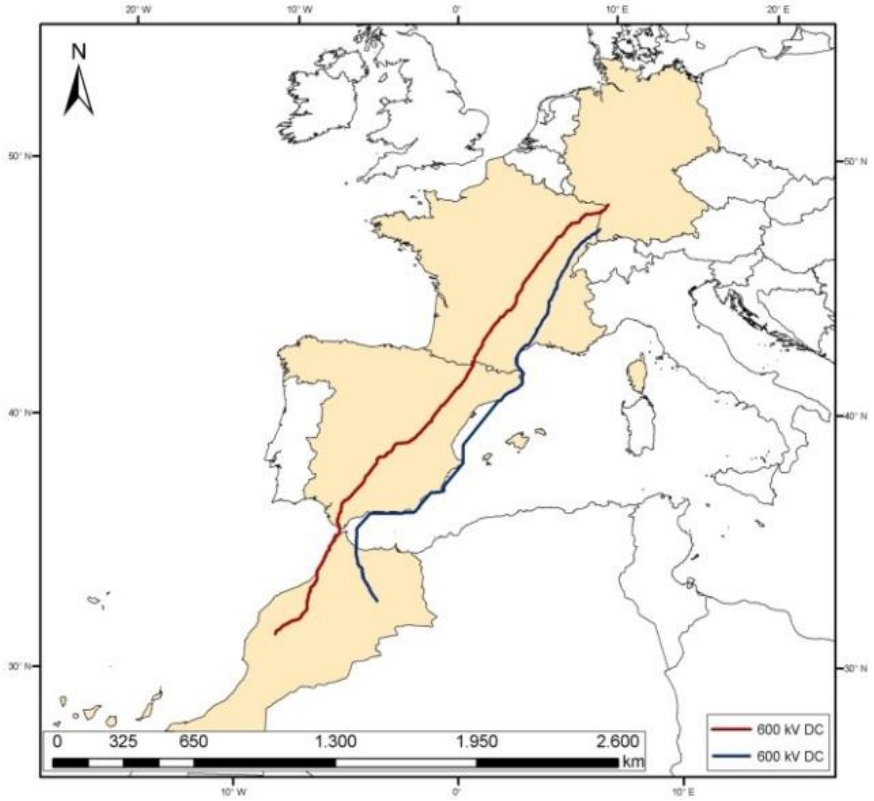
contact: denis.hess@dlr.de

Source: http://www.ribapylondesign.com/

Further steps

- preparation of a handbook for public participation
- publication of further scientific studies on the necessity of dispatchable solar electricity imports to Baden-Wuerttemberg on a multilingual website
- questioning of citizens in case studies in exemplary communities
- detailed cost-benefit analysis with risk assessment
- cooperation with ENTSO, TransnetBW, RTE, REE, ONEE in preparation for the inclusion in the "Union List" of a project with common interests (EU Regulation 347/2013)
- support of the necessary application documents and the required measures
- search for suitable project responsible

Communication platform for online public participation

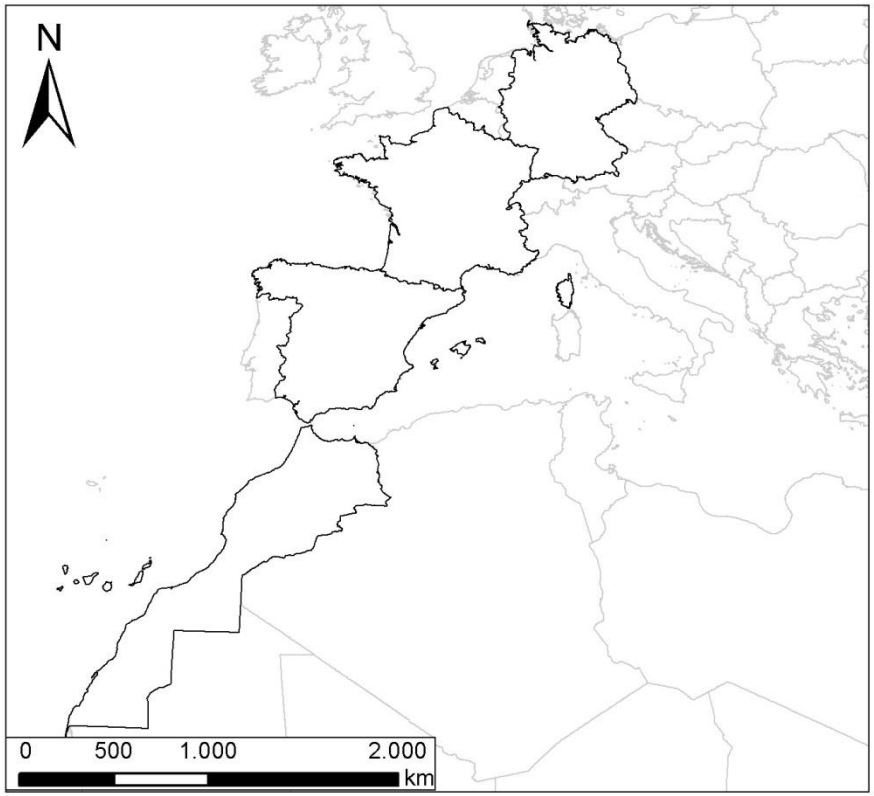


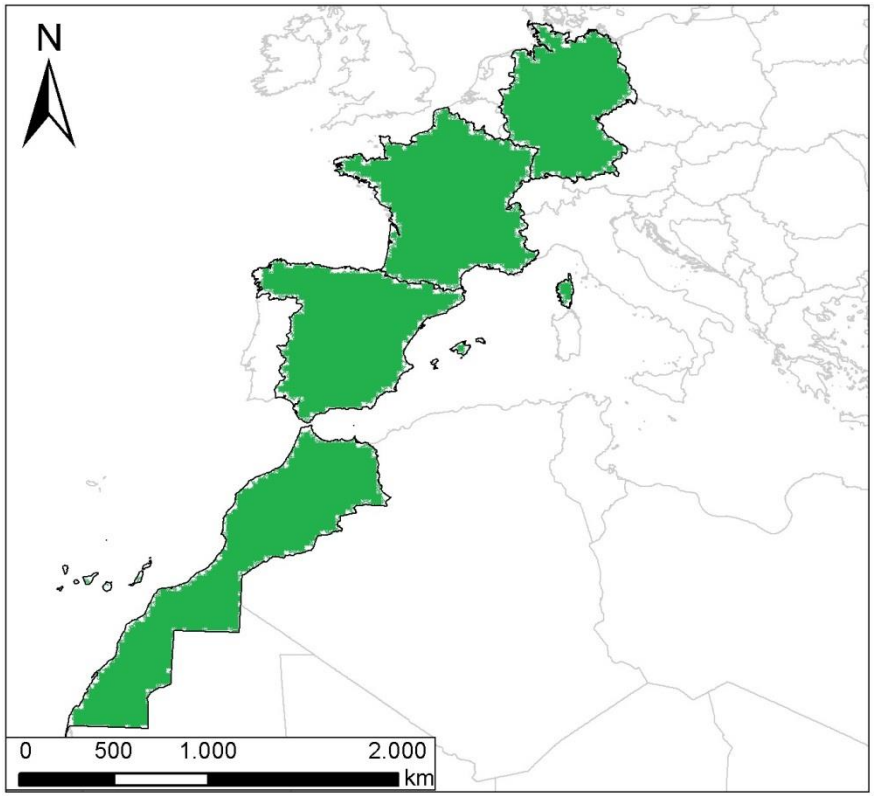
DLR

green: in favour
red: refusal
white: not yet decided

Declaration of intent on state level

exemplary scientific model





green: in favour
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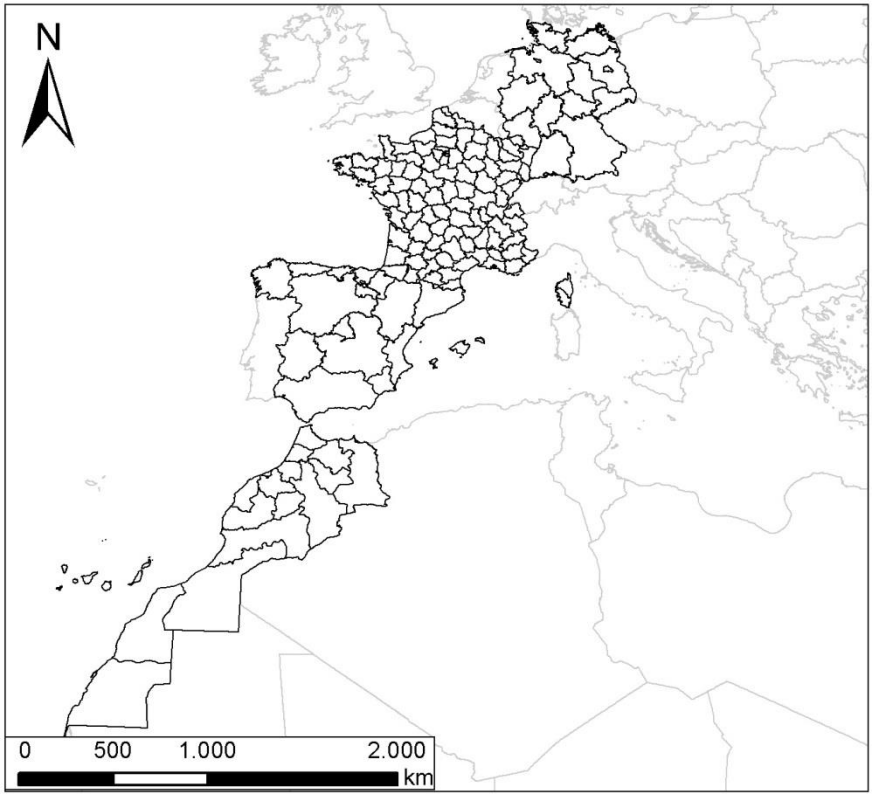
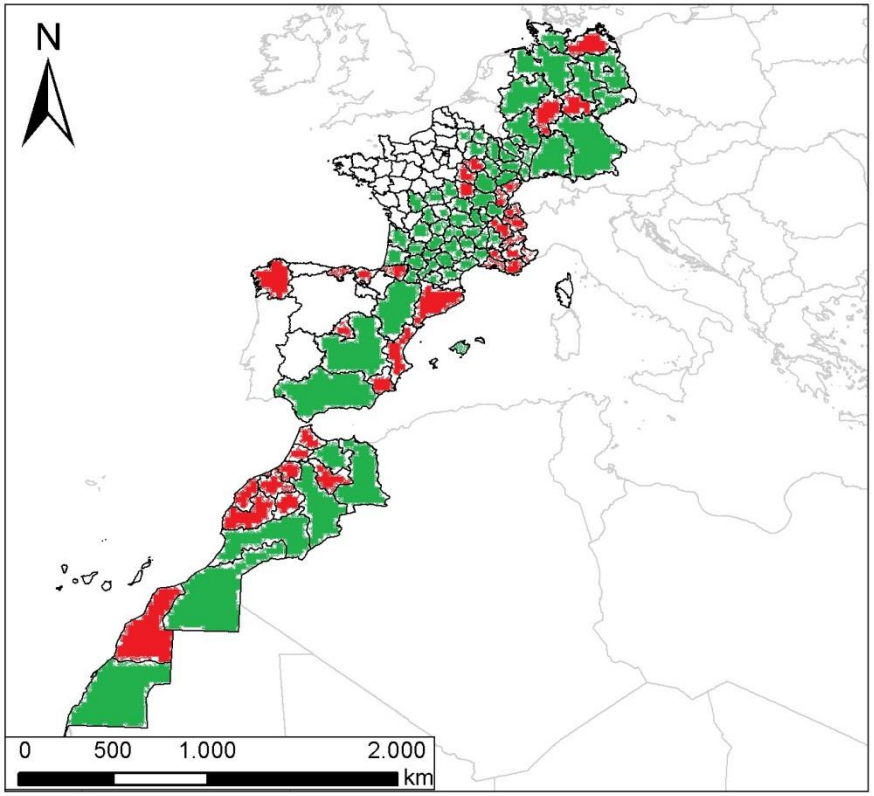
Declaration of intent on regional level

exemplary scientific model





DLR

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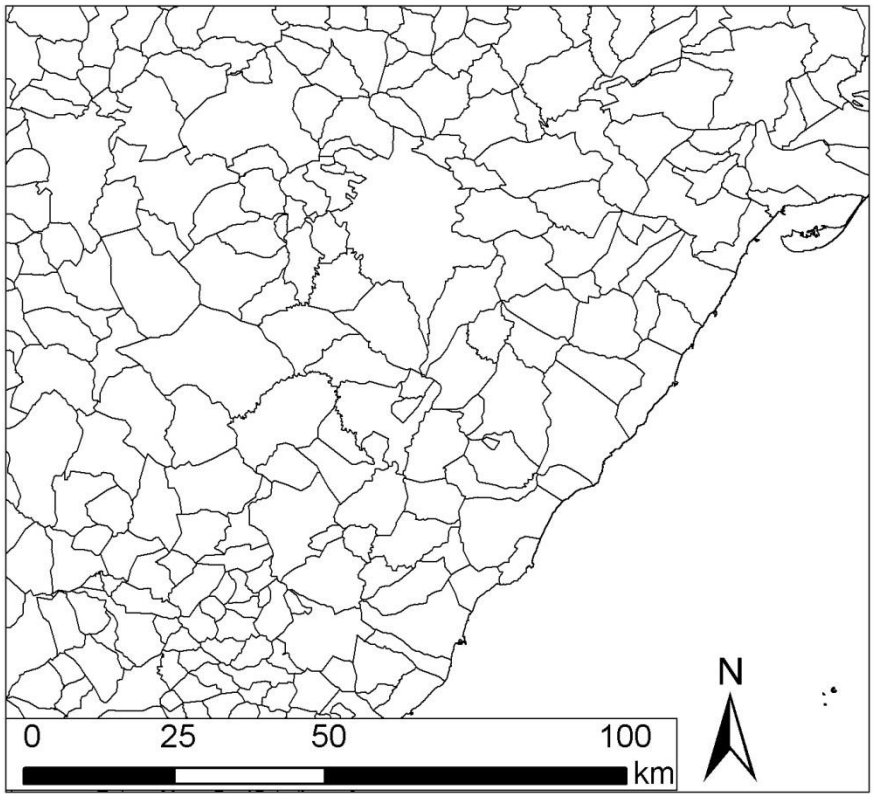
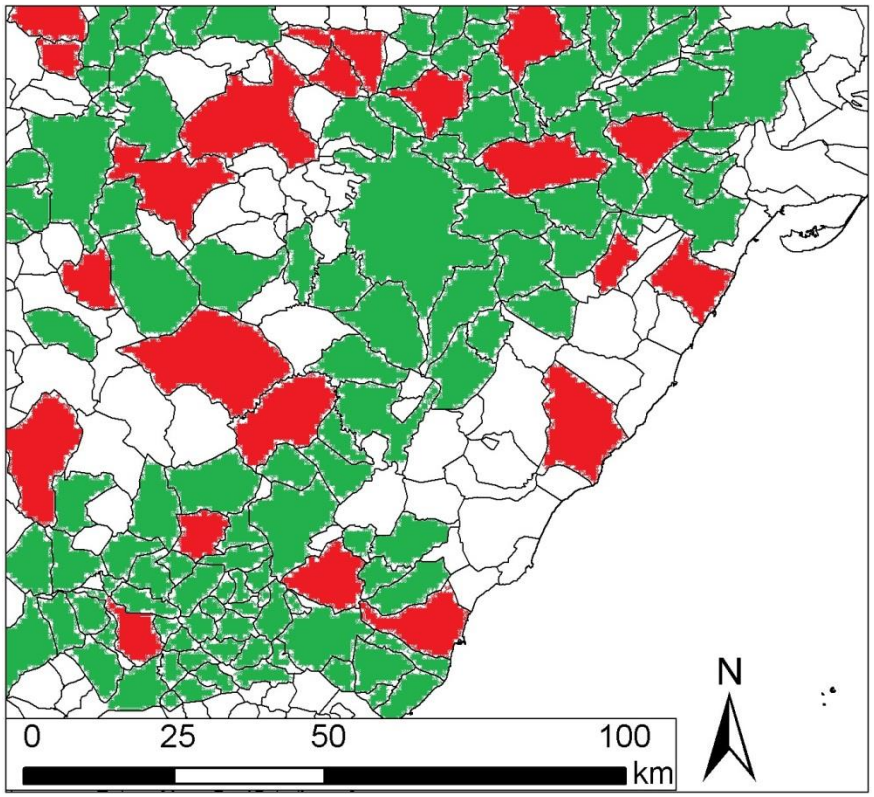
Declaration of intent on municipal level

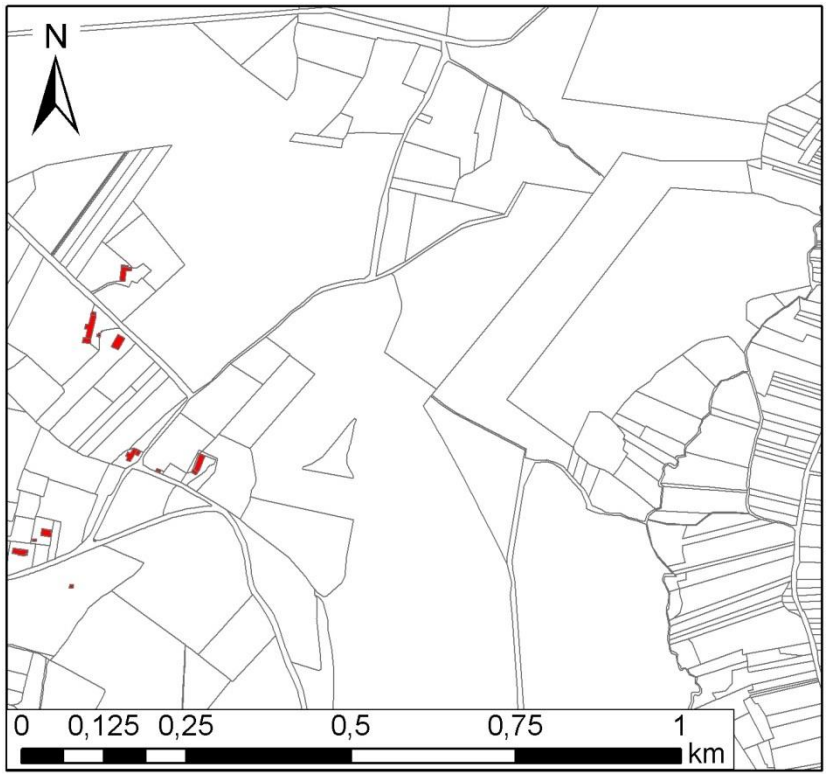


exemplary scientific model

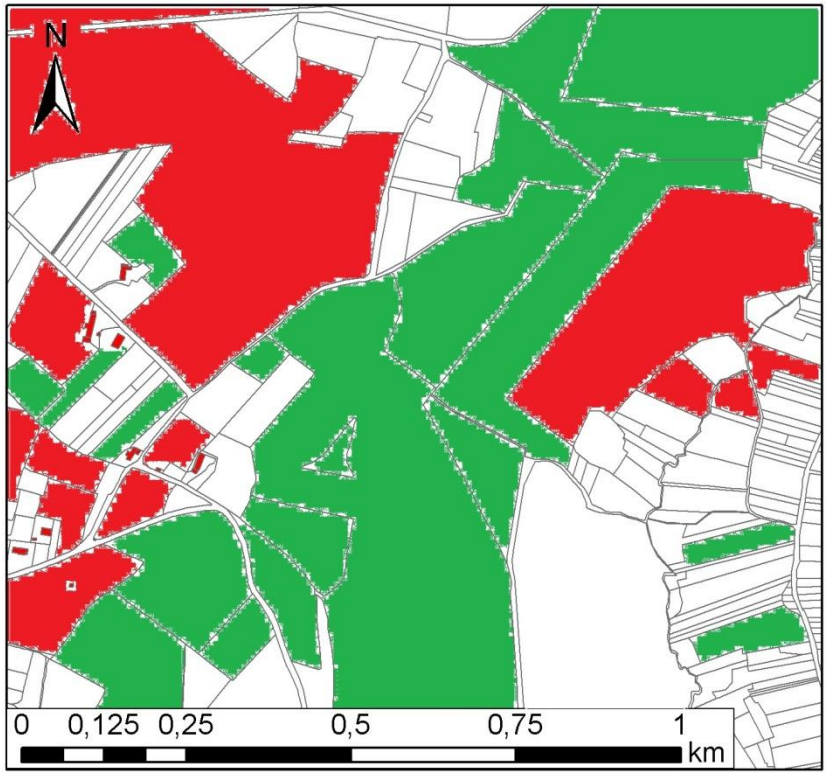


green: in favour
red: refusal
white: not yet decided

Declaration of intent on owner level



exemplary scientific model



On the interactive website can also appear:

- Image video about this potential project (animation of the power plant function, need in the energy system of a Central European control area, data and interviews with affected people of the power station, the transmission line and electricity customers)
- All current activities with citizens, in politics, science and economy
- Schedule of citizen participation and overall schedule
- All data in the field of economy, ecology, technology, social and institutional
- Already achieved progress and critique